CONSTRUCTION AND DEMOLITION WASTE LANDFILLS

Prepared for

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by

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EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) is currently developing a rule addressing non-municipal facilities (industrial waste facilities, including construction and demolition waste landfills) that may receive hazardous wastes from conditionally exempt small quantity generators (CESQGs), or generators of less than 100 kilograms per month of hazardous waste. This report, prepared in support of EPA's rulemaking, presents information on construction and demolition (C&D) waste landfills, i.e., landfills that receive materials generated from the construction or destruction of structures such as buildings, roads, and bridges. C&D waste landfills are being examined because the Agency believes that the largest potential impact from this rulemaking will be on these facilities.

BACKGROUND

The 1984 Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA) required EPA to revise the existing standards and guidelines governing the management of household hazardous wastes and hazardous wastes from small quantity generators. EPA responded in 1991 by revising the existing criteria for solid waste disposal facilities and practices (40 CFR Part 257). In 1991 EPA issued revised criteria in 40 CFR Part 258 for municipal solid waste landfills (MSWLFs) that receive household hazardous wastes and CESQG wastes. EPA did not establish revised criteria for non-municipal facilities and subsequently was sued by the Sierra Club. A consent agreement was reached in January 1994, and EPA is now fulfilling the remainder of the HSWA mandate by regulating non-municipal facilities that may receive CESQG wastes. The final rule must be signed by the EPA Administrator by May 15, 1995. The rule will require facilities receiving CESQG wastes to have adequate ground-water monitoring, corrective action requirements, and location restrictions.

COMPOSITION OF C&D WASTE

Information on the composition of C&D waste is presented below. Most of this information was compiled from the literature by the National Association of Demolition Contractors (NADC); a small number of other readily available sources were used as well. These source documents provide only snapshots of the C&D waste stream in specific locations and at specific points (e.g., generation) rather than providing a complete cradle-to-grave picture of C&D wastes nationwide, or of the portion landfilled.

C&D waste is generated from the construction, renovation, repair, and demolition of structures such as residential and commercial buildings, roads, and bridges. The composition of C&D waste varies for these different activities and structures. Overall, C&D waste is composed mainly of wood products, asphalt, drywall, and masonry; other components often present in significant quantities include metals, plastics, earth, shingles, insulation, and paper and cardboard.

C&D debris also contains wastes that may be hazardous. The source documents identify a number of wastes that are referred to using such terms as "hazardous," "excluded," "unacceptable," "problem," "potentially toxic," or "illegal." It is not necessarily true that all of these wastes meet the definition of "hazardous" under Subtitle C of RCRA, but they provide an indication of the types of hazardous wastes that may be present in the C&D waste stream. They can be divided into four categories:

- Excess materials used in construction, and their containers. *Examples: adhesives and adhesive containers, leftover paint and paint containers, excess roofing cement and roofing cement cans;*
- Waste oils, grease, and fluids. *Examples: machinery lubricants, brake fluid, form oil, engine oil;*
- Other discrete items. *Examples: batteries, fluorescent bulbs, appliances;* and
- Inseparable constituents of bulk items. *Examples: formaldehyde present in carpet, treated or coated wood.*

Some of these components are excluded from C&D landfills by state regulations.

C&D LANDFILL LEACHATE QUALITY

Construction and demolition landfill leachate sampling data were collected from states and from the general literature by NADC. Leachate sampling data for 305 parameters sampled for at one or more of 21 C&D landfills were compiled into a database.

Of the 305 parameters sampled for, 93 were detected at least once. The highest detected concentrations of these parameters were compared to regulatory or health-based "benchmarks," or concern levels, identified for each parameter. Safe Drinking Water Act Maximum Contaminant Levels (MCLs) or Secondary Maximum Contaminant Levels (SMCLs) were used as the benchmarks if available. Otherwise, health-based benchmarks for a leachate ingestion scenario were identified; these were either reference doses (RfDs) for non-carcinogens, or 10^{-6} risk-specific doses (RSDs) for carcinogens. Benchmarks were unavailable for many parameters because they have not been studied sufficiently.

Of the 93 parameters detected in C&D landfill leachate, 24 had at least one measured value above the regulatory or health-based benchmark.[1] For each of the parameters exceeding benchmarks (except pH), the median leachate concentration was calculated and compared to its benchmark. The median value was first calculated among the samples taken at each landfill, and then across all landfills at which the parameter was detected. Due to anomalies and inconsistencies among the sampling equipment used at different times and at different landfills, non-detects were not considered in determining median values; i.e., the non-detects were discarded before calculating both individual landfill concentration medians and medians across landfills. Thus, the median leachate concentrations represent the median among the detected values, rather than the median among all values. The median concentration among all values would in most cases have been lower than those calculated here.

Based on (1) the number of landfills at which the benchmark was exceeded and (2) a comparison between the median detected concentration and the benchmark, seven constituents emerge as being potentially problematic. They are listed in the table below. Also shown are the number of landfills at which the constituent was sampled, the

C&D LANDFILL LEACHATE - POTENTIALLY PROBLEMATIC CONSTITUENTS

Constituent	No. Landfills Sampled	No. Landfills Detected	No. Landfills > Benchmark	Ratio of Median to Benchmark
1,2-Dichloroethane	9	3	3	4
Methylene chloride	9	4	3	3
Cadmium	19	14	12	2
Iron	20	20	19	37
Lead	18	15	13	4
Manganese	14	14	13	59
Total dissolved solids	18	17	15	4

[1] In the case of pH, the "exceedances" were actually pH values below the regulatory range.

number of landfills at which the constituent was detected, the number of landfills at which the constituent was detected above its benchmark, and the ratio of the median detected concentration to the benchmark.

For three of the seven parameters listed in the table (iron, manganese, and TDS), the benchmarks are secondary MCLs (SMCLs), which are set to protect water supplies for aesthetic reasons (e.g., taste) rather than for health-based reasons. None of the remaining four parameters exceeds its benchmark by a factor of 10 or more, indicating that concentrations in ground water where monitoring wells or drinking water wells may be located are likely to fall below the health-based benchmarks.

Conclusions regarding C&D landfill leachate quality must be viewed with an understanding of the data limitations. The most important limitation is that the 21 landfills represented in this report comprise just over one percent of the approximately 1,800 C&D landfills in the United States. Thus, the representativeness of the sample is questionable. Other limitations are discussed in the body of the report.

STATE REGULATIONS

State statutes and regulations for C&D landfills were summarized, and similarities and differences between current state requirements for C&D landfills and federal requirements for MSWLFs were evaluated. The following summarizes the key findings:

- **All states regulate off-site C&D landfills to some extent**. Thirteen states require off-site C&D landfills to meet state MSWLF requirements (in many states, these requirements are not as stringent as the federal MSWLF requirements found in 40 CFR Part 258), while the remaining 37 have developed separate regulations that are specific to off-site C&D landfills.[2]

- **Only seven states exempt on-site C&D landfills from regulatory requirements**. Of the remaining 43 states, 11 require on-site C&D landfills to meet state sanitary landfill requirements (in many states, these requirements are not as stringent as 40 CFR Part 258), 8 have developed separate regulations applicable to only on-site landfills, and the remaining 24 have extended the regulations for off-site landfills to on-site landfills.

- **Sixteen states mandate location restrictions, ground-water monitoring, and corrective action for off-site C&D landfills**. These requirements, however, vary in stringency relative to 40 CFR Part 258. For example, **only two states have location restrictions, ground-water monitoring, and corrective action requirements for off-site C&D landfills that are at least as stringent as 40 CFR Part 258**.

- **The most common 40 CFR Part 258 location restrictions that states apply to C&D landfills relate to: airports and bird hazards, wetlands, and floodplains**. Several states have moved beyond federal requirements and <u>prohibit</u> the siting of on-site (eight states) and off-site (nine states) C&D landfills in floodplains. Fewer states have adopted the 40 CFR Part 258 requirements regarding faults, seismic zones, and unstable areas.

- **A majority of states impose additional location restrictions on C&D landfills**. The most common additional restrictions are: near ground and surface waters, and near endangered species habitats.

- **Twenty-nine states (nearly 60 percent) require off-site C&D landfills to monitor ground water**. Of these 29 states, 5 have requirements substantially similar to 40 CFR Part 258, while 24

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[2]Ohio expects to have specific C&D management requirements effective by the end of 1995.

have requirements that are less stringent.[3] **The remaining 21 states do not require ground-water monitoring requirements**. Of these 21, however, 12 "may" require ground-water monitoring if the regulatory authority deems it necessary.

- **Twenty-four states (nearly 50 percent) require on-site C&D landfills to monitor ground water**. Of these 24, only 4 have requirements substantially similar to 40 CFR Part 258, while 20 have requirements that are less stringent. **The remaining 26 states do not require ground-water monitoring**. Of these 26, 9 states "may" require ground-water monitoring if the regulatory authority deems it necessary.

- **Twenty-two states have corrective action requirements for off-site C&D landfills.** These states either require the permit applicant to submit a corrective action plan with the permit application, or require the facility owner/operator to submit a plan after a release to ground water is detected.

- **Sixteen states have corrective action requirements for on-site C&D landfills**. Again, these states either require the permit applicant to submit a corrective action plan with the permit application, or require the facility owner/operator to submit a plan after a release to ground water is detected.

- **States also have mandated permit, design and operating, post-closure, and financial assurance requirements for both on-site and off-site C&D landfills**. The most common of these is permitting requirements. Respectively, 45 and 38 states require off-site and on-site C&D landfills to obtain a permit.[4] Thirty-four states require some post-closure time period for off-site landfills (11 require at least 30 years and 23 require less than 30 years). Additionally, 33 states require off-site C&D landfills to obtain financial assurance for closure, while 32 require it for post-closure care.

- **Twenty-four states prohibit <u>all</u> hazardous wastes from disposal at off-site C&D landfills.** In addition, three and four states require that only inert waste and C&D waste be disposed, respectively. Fourteen states do not specifically prohibit disposal of all hazardous wastes at off-site C&D landfills. In general, the regulations for these states note that only waste specified in permit may be accepted, or only "regulated" or "controlled" hazardous waste is prohibited. Finally, five states do not specifically identify any restrictions on waste disposal at off-site C&D landfills.

[3]Ohio currently does not have ground-water monitoring, but monitoring is expected to be part of C&D management regulations that should be finalized by the end of 1995.

[4]Ohio requires a permit for C&D landfills.

CHAPTER 1
INTRODUCTION

This report presents information on construction and demolition (C&D) waste landfills. These are landfills that receive materials generated predominantly from the construction or destruction of structures such as buildings, roads, and bridges. There are currently over 1,800 C&D waste landfills operating in the United States.

This report was written in support of a rulemaking currently being developed by the U.S. Environmental Protection Agency (EPA). This chapter provides a background discussion of this rulemaking, and then discusses the purpose and organization of this report.

REGULATORY BACKGROUND

The Resource Conservation and Recovery Act (RCRA), passed in 1976, required the Environmental Protection Agency (EPA) to promulgate standards and guidelines for the management of solid wastes. In response to this mandate, EPA promulgated regulations for the management of hazardous wastes under Subtitle C of RCRA, and for non-hazardous wastes under Subtitle D. The Subtitle C standards applied to all facilities generating more than 1,000 kg/mo of hazardous wastes, but conditionally exempted from full regulation facilities generating less than this amount. Subtitle D guidelines address the management of all other solid wastes, such as municipal wastes and non-hazardous industrial wastes (including construction and demolition wastes).

In 1984, Congress passed the Hazardous and Solid Waste Amendments (HSWA), which made several changes to RCRA. One important change was the creation of two categories of small quantity hazardous waste generators: generators of 100 to 1,000 kg/mo, and generators of less than 100 kg/mo. HSWA added specific provisions for the first category, but gave EPA discretion as to whether to promulgate new requirements for the second. EPA has since defined generators of less than 100 kg/mo as conditionally-exempt small quantity generators, or CESQGs. CESQGs are responsible for the proper management of their wastes, but are not required to comply with many of the Subtitle C regulations specified for larger hazardous waste generators.

Another important change imposed by HSWA was the addition of Section 4010 to Subtitle D, requiring EPA to promulgate revised criteria addressing the management of household hazardous wastes and hazardous wastes from small quantity generators. EPA responded in October 1991 by promulgating the revised Municipal Solid Waste Landfill (MSWLF) Criteria (40 CFR Part 258). This partially fulfilled the HSWA mandate by addressing household hazardous wastes and CESQG wastes that are disposed in MSWLFs. After a consent agreement with the Sierra Club on January 28, 1994, EPA is now fulfilling the remainder of the HSWA mandate by regulating CESQG wastes that are disposed in non-municipal facilities. The final rule must be signed by the EPA Administrator by May 15, 1995. The rule will require non-municipal facilities receiving CESQG wastes to have adequate ground-water monitoring, corrective action requirements, and location restrictions.

FOCUS ON C&D LANDFILLS

CESQGs currently send their wastes to many different types of Subtitle D waste management units other than MSWLFs, including the following:

- Commercial Subtitle D industrial waste landfills;
- On-site Subtitle D industrial waste management units such as landfills, surface impoundments, land treatment units, and waste piles; and
- C&D waste landfills.

EPA believes that the only waste management units that may be impacted significantly by this rulemaking are the C&D landfills. The Agency believes that most of the 10 to 20 commercial Subtitle D industrial waste landfills in existence today already have adequate ground-water monitoring, corrective action requirements, and location restrictions. EPA also believes that CESQGs currently disposing of their wastes in on-site Subtitle D waste management units will simply start sending the hazardous portion of their waste stream off site, at relatively low cost.

On the other hand, the rulemaking will have an impact on C&D landfills. C&D landfills are therefore the focus of this report.

SCOPE AND ORGANIZATION OF THIS REPORT

This report examines C&D waste characteristics, C&D landfill leachate quality, and state regulations addressing C&D waste management facilities.

- Chapter 2 discusses the composition of C&D wastes, including any hazardous materials or constituents that are found;

- Chapter 3 presents information on the quality of C&D landfill leachate, based on sampling data taken from landfills around the country; and

- Chapter 4 presents a detailed summary of state regulations pertaining to C&D facilities. It identifies states that have regulations related to ground-water monitoring; corrective action; location restrictions; and facility design, operation, closure, and/or post closure care; and provides the specifics of those requirements.

The first two chapters are based predominantly on information supplied to EPA by the National Association of Demolition Contractors (NADC), supplemented with a small number of other readily available studies. The chapter on state regulations is based on original research performed for this report.

CHAPTER 2
CHARACTERISTICS OF CONSTRUCTION AND DEMOLITION WASTES

This chapter presents information on the composition and characteristics of the C&D waste stream based on four source documents:

- The National Association of Demolition Contractors's (NADC's) *C&D Waste Characterization Database: Volume 1 - Compilation of Report Excerpts* (1994);

- NADC's *C&D Waste Characterization Database: Volume 1 - Compilation of Articles* (1994);

- Hanrahan's *Construction and Demolition Debris Disposal Issues: An Alachua County Perspective* (1994); and

- Lambert and Domizio's *Construction and Demolition Waste Disposal: Management Problems and Alternative Solutions* (1993).

The source documents provide only snapshots of the C&D waste stream in specific locations (e.g., Vermont) and at specific points (e.g., at generation) rather than providing a complete cradle-to-grave picture of the nationwide C&D waste stream, or of the portion that is landfilled. This report reflects that segmented characterization of the waste stream and includes waste characterization information based on generated wastes. In some areas, a large portion of the complete C&D waste stream may be recycled, burned, left on site, or illegally disposed (Apotheker, 1990; Piasecki et al., 1990; Spencer, 1991; Lambert and Domizio, 1993; McGregor et al., 1993); thus, the characterizations presented in this report may be somewhat different from those of the landfilled portion of the waste stream. In Vermont, for example, only about one-third of the waste stream went to landfills in 1989 (Spencer, 1991).

The first section of this chapter discusses factors that influence C&D waste composition and characteristics. The second section provides information on components and their proportions in the C&D waste stream. The final section focuses specifically on the components and constituents of C&D waste that the source documents characterize using the terms "hazardous," "excluded," "contaminants," "chemical constituents that could affect the use of the waste as fuel," "special," "unacceptable," "problem," "potentially toxic," "nonhazardous restrictive," or "illegal." Throughout this chapter these components are referred to as "problematic." These "problematic" wastes are **not** necessarily wastes that are classified as hazardous under RCRA Subtitle C.

FACTORS THAT INFLUENCE C&D WASTE COMPOSITION

C&D wastes are categorized in a variety of ways, and each category produces wastes with different composition and characteristics. For example, road C&D waste differs from bridge waste, which differs from building waste. Whereas road C&D generates large quantities of just a few different waste items (mainly asphalt and concrete), building C&D generates many different waste items in smaller amounts (with wood as the largest single item). Within the category of building C&D waste, the size and type of the building (e.g., an apartment building versus a single-family house) affects the composition of the waste. Even for one building type (e.g., a single-family house), the waste generated depends on the activity conducted (i.e., new construction, renovation, or demolition). For example, construction generally produces "clean," unaltered, and separate waste items (e.g., unpainted wood, new concrete) (MVC, 1992). In contrast, demolition wastes may include more items that have been altered or mixed (e.g., wood painted with lead-based paint, concrete with hazardous waste spilled on it) (MVC, 1992).

Thus, three main factors affect the characteristics of C&D waste (MVC, 1992):

- Structure type (e.g., residential, commercial, or industrial building, road, bridge);
- Structure size (e.g., low-rise, high-rise); and
- Activity being performed (e.g., construction, renovation, repair, demolition).

Additional factors that influence the type and quantity of C&D waste produced include (MVC, 1992; McGregor et al., 1993):

- Size of the project as a whole (e.g., custom-built residence versus tract housing);
- Location of the project (e.g., waterfront versus inland, rural versus urban);
- Materials used in construction (e.g., brick versus wood);
- Demolition practices (e.g., manual versus mechanical);
- Schedule (e.g., rushed versus paced); and
- Contractors' "housekeeping" practices.

Other factors do not affect the type and quantity of C&D waste **produced**, but do affect the type and quantity **reported** in the source documents and therefore in this report. These include:

- How state regulations define what is and is not acceptable as C&D waste;
- Where in the waste stream the C&D waste is measured (e.g., generation point, recycling station, landfill); and
- How the C&D waste is measured (e.g., by volume or weight).

The next section provides information on the components of C&D waste and their proportions in the waste stream.

COMPONENTS OF C&D WASTE

Overall, C&D waste streams are comprised mainly of wood products, asphalt, drywall (gypsum)[5], and masonry (e.g., concrete, bricks). Other notable components include metals, plastics, earth, shingles, and insulation. In one county, waste identified by the source document as "hazardous" has been estimated to comprise 0.4 percent of construction waste by weight (Triangle J Council of Governments, 1993)[6]; this is discussed further in the final section of this chapter. Table 2-1 provides a complete list of components of C&D wastes mentioned in the source documents. The bold print denotes the "problematic" components, i.e., components that the source documents refer to as "hazardous," "excluded," "contaminants," "chemical constituents that could affect the use of the waste as fuel," "special," "unacceptable," "problem," "potentially toxic," "nonhazardous restrictive," or "illegal."

In general, wood comprises one-quarter to one-third of the C&D waste stream. Other generalizations are hard to make because (1) different studies address different segments of the nation's

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5 Drywall is excluded from some C&D landfills because anaerobic breakdown of gypsum produces hydrogen sulfide.

6 Hazardous waste percentage estimate is for the 1990 Orange County, North Carolina construction waste stream (SCS Engineers, 1991 as cited in Triangle J Council of Governments, 1993).

TABLE 2-1
COMPONENTS OF C&D WASTE

ASPHALT paving shingles	**PAINT** **paint containers and waste** **paint products**	**WALL COVERINGS** **drywall (gypsum)** plaster
EARTH dirt sand, foundry soil	**PAPER PRODUCTS** cardboard fiberboard, paperboard paper	**WOOD** cabinets composites millends pallets, shipping skids, and crating lumber particle board plywood siding trees: limbs, brush, stumps, and tops veneer
ELECTRICAL fixtures wiring	**PETROLEUM PRODUCTS** **brake fluid** **form oil** **fuel tanks** **oil filters** **petroleum distillates** **waste oils and greases**	**WOOD CONTAMINANTS** **adhesives and resins** **laminates** **paintings and coatings** **preservatives** **stains/varnishes** **other chemical additives**
INSULATION **asbestos** building extruded polystyrene (rigid) **fiberglass (bat)** roofing	**PLASTICS** buckets pipe (PVC) polyethylene sheets styrofoam sheeting or bags laminate	**MISCELLANEOUS** **adhesives and adhesive cansaerosol cans** **air conditioning units** **appliances ("white goods")** **batteries** **carpeting**
MASONRY AND RUBBLE bricks cinder blocks concrete mortar, excess porcelain rock stone tile	**ROOF MATERIALS** **asbestos shingles** roofing, built up **roofing cement cans** roofing shingles roofing tar tar paper	**caulk (tubes)** ceiling tiles **driveway sealants (buckets)** **epoxy containers** **fiberglass** fines fireproofing products (overspray) floor tiles **furniture** **garbage**
METAL aluminum (cans, ducts, siding) brass fixtures, plumbing flashing gutters **mercury from electrical switches** iron **lead** nails pipe (steel, copper) sheet metal steel (structural, banding, decking, rerod) studs, metal wire (e.g., copper)	**VINYL** siding flooring doors windows	glass **lacquer thinners** leather **light bulbs, fluorescent and HID** light bulbs, other linoleum organic material packaging, foam **pesticide containers** rubber **sealers and sealer tubes** sheathing silicon containers **solvent containers and waste** street sweepings textiles **thermostat switches** **tires** **transformers** water treatment plant lime sludge

Source: Summarized from NADC, 1994a and 1994b; Hanrahan, 1994; and Lambert and Domizio, 1993.

C&D waste stream (e.g., road and bridge waste may be excluded from some studies; information in another study may be for waste from construction only or demolition only) and (2) C&D waste composition varies greatly from one category to another. The graphs and tables in this section provide examples of the composition of portions of the C&D waste stream. Note that they vary with location (e.g., Florida versus Vermont) and category of waste (e.g., construction versus demolition). Viewed together, they provide a good overall picture of the North American C&D waste stream, and show important differences among different categories of C&D waste.

C&D Waste Including Road and Bridge Waste (Vermont)

Figure 2-1 provides a picture of the composition of Vermont's complete C&D waste stream by weight, based on a comprehensive C&D generation study. Asphalt comprises approximately one-half of the waste stream, wood one-quarter, and concrete one-sixth (Cosper et al., 1993).

C&D Waste Excluding Road and Bridge Waste (Florida)

Figure 2-2 provides an example of the composition by volume of the C&D waste stream received at a C&D recycling facility in Florida. Although the source document (Cosper et al., 1993) states that the facility accepts "the complete C/D waste stream," it appears that the facility receives the complete **building** C&D waste stream, but does not receive wood or bridge waste, because asphalt is not listed as a component of the waste. Approximately one-third of the waste volume is wood (Cosper et al., 1993). Drywall comprises one-sixth and paper and cardboard together comprise one-sixth of the total volume (Cosper et al., 1993).

Construction-only Waste Versus Demolition-only Waste

Approximately one-third of the construction waste volume in Toronto is wood, and masonry and tile comprise less than one-sixth of the construction waste (Figure 2-3) (THBA, 1991). Demolition waste is also comprised of approximately one-third wood (in the U.S.), but concrete makes up over one-half of demolition waste (Figure 2-4) (Chatterjee-U.S. Army as cited in SPARK, 1991).

C&D Waste by Housing Type

Table 2-2 compares residential construction waste to commercial construction waste in the Twin Cities, Minnesota. Wood comprises one-fifth to one-third of the waste stream in both cases. Concrete, brick, and steel waste are greater from commercial construction than from residential, as would be expected.

COMPONENTS OF C&D WASTE THAT ARE POTENTIALLY "PROBLEMATIC"

Hazardous wastes comprise a small percentage of the C&D waste stream (McGregor et al., 1993), and can potentially cause adverse effects to human health and ecosystems (Lambert and Domizio, 1993). For example, inhalation of urea formaldehyde (a resin used in insulation and as a wood preservative) has caused a health syndrome called "ultra-sensitive allergies" in demolition workers (Lambert and Domizio, 1993). Creosote (a wood preservative) can potentially leach into ground water and discharge into surface water, possibly adversely affecting drinking water or aquatic life if concentrations reach high enough levels (Lambert and Domizio, 1993).

This section describes the "problematic" components and constituents of C&D waste and, where information was available (i.e., for treated and coated wood), the proportion of those constituents in the

FIGURE 2-1
COMPOSITION OF C&D WASTE STREAM IN VERMONT (BY WEIGHT; 1989 DATA)
(Source: C.T. Donovan Associates, 1990)

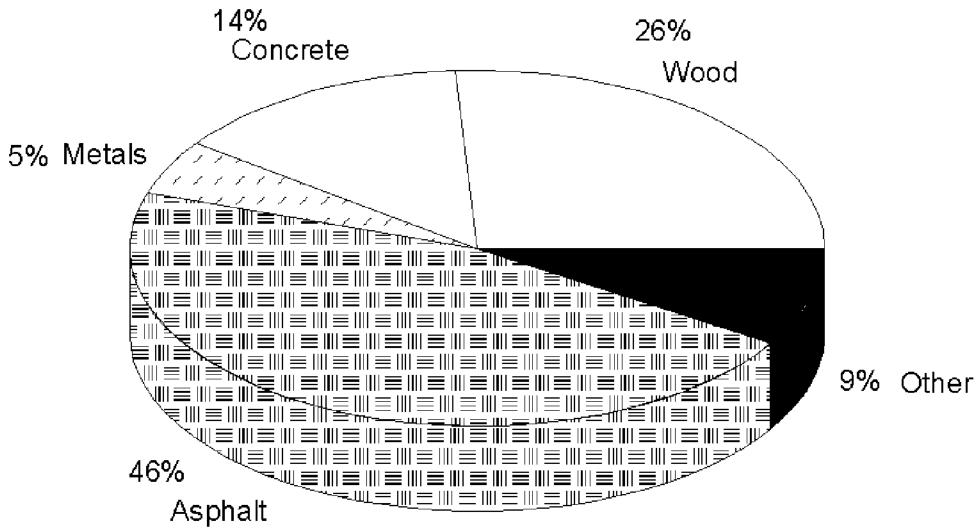

FIGURE 2-2
COMPOSITION OF THE BUILDING C&D WASTE STREAM IN FLORIDA (BY VOLUME)
(Source: Wood, 1992 as cited in Cosper et al., 1993)

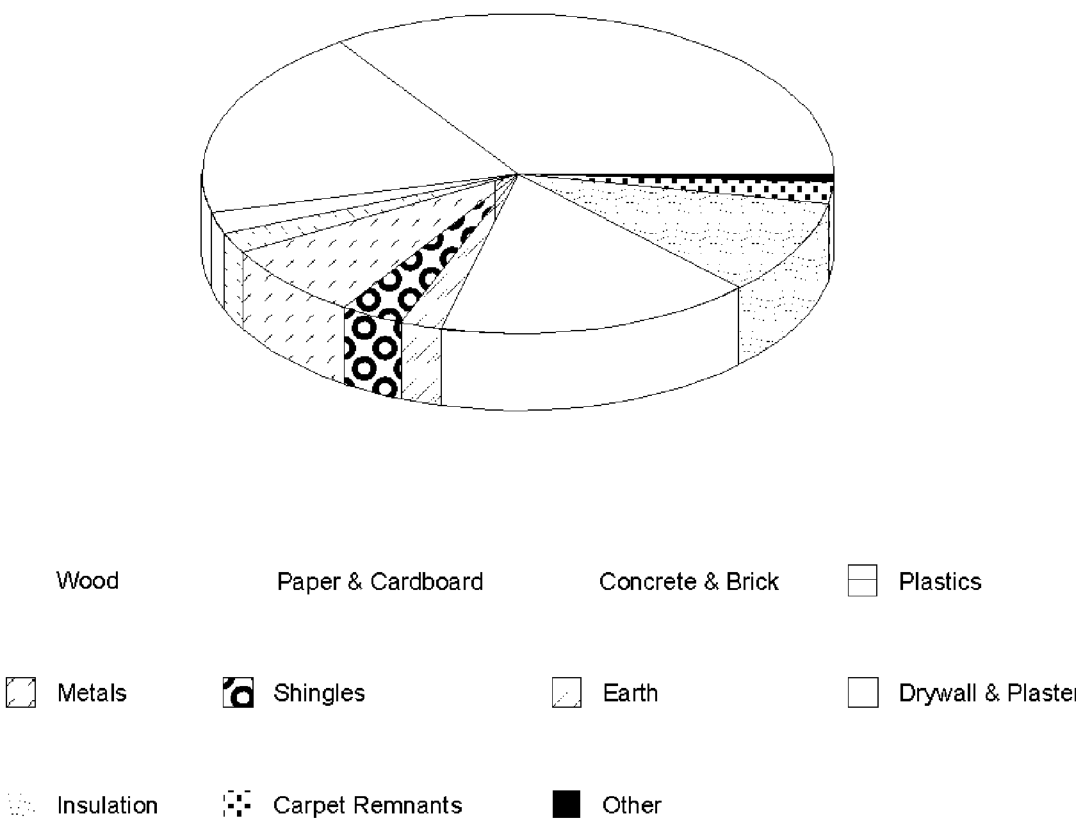

FIGURE 2-3
COMPOSITION OF CONSTRUCTION WASTE IN TORONTO (BY VOLUME)
(Source: THBA, 1991)

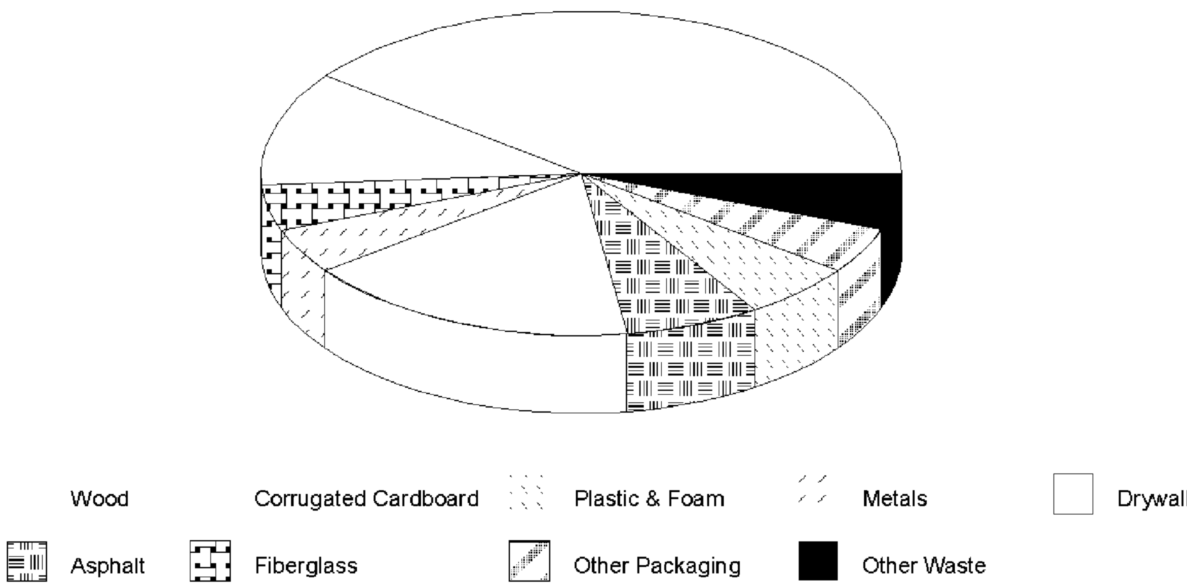

FIGURE 2-4
COMPOSITION OF U.S. DEMOLITION WASTE
(Source: Chatterjee-U.S. Army, as cited in SPARK, 1991)

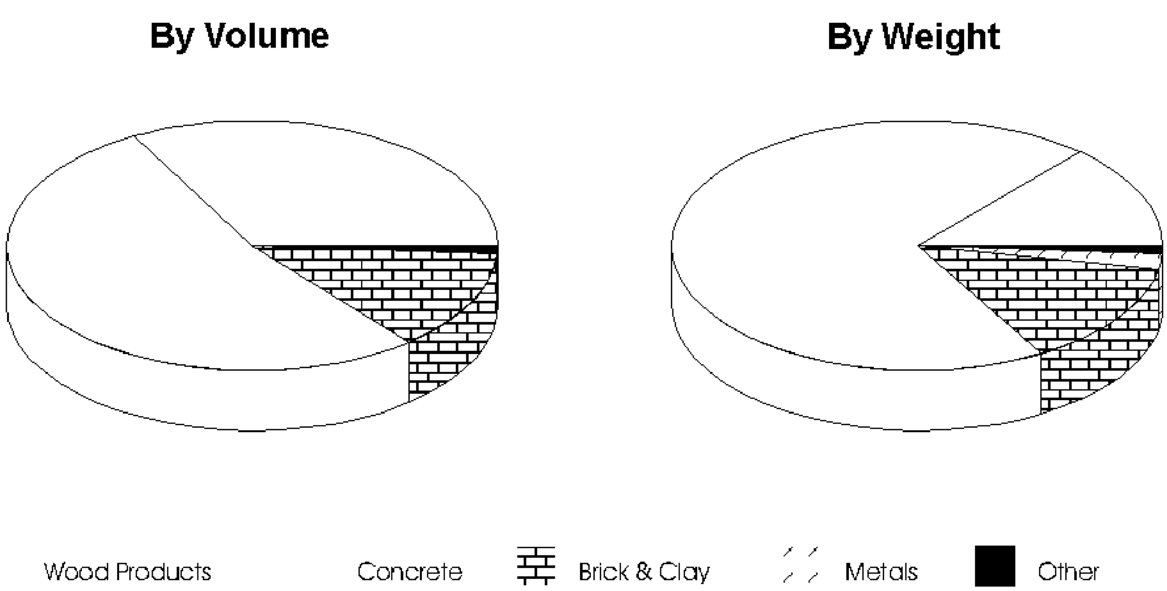

TABLE 2-2
COMPOSITION OF CONSTRUCTION WASTE BY CONSTRUCTION TYPE
IN THE TWIN CITIES IN MINNESOTA (BY VOLUME) (Source: Lauer, 1993)

Waste Type	**Residential Construction**	**Commercial Construction**
Wood	20-35%	20-30%
Crates & pallets	--	1-5%
Cardboard	5-15%	5-10%
Paper packaging	<1%	~3%
Concrete & block	1-8%	10-20%
Brick	--	1-5%
Drywall	10-20%	5-10%
Electrical wire	<1%	~2%
Shingles	1-8%	--
Fiberboard	1-8%	--
Steel	<1%	1-8%
Plastic sheeting and bags	<1%	~3%
Polystyrene insulation	--	~3%
Overspray from fireproofing products	--	0-5%
Notable other materials (comprising <1% each)		
carpet scrap	<1%	<1%
solvent containers	--	<1%
epoxy containers	--	<1%
silicone containers	--	<1%
plastic laminate	--	<1%
Possible "problem materials"		
driveway sealants	<1%	--
adhesive containers	<1%	<1%
caulking containers	<1%	<1%
paint cans (including frozen or damaged)	<1%	<1%

-- Indicates that the waste was not listed under that category.

waste item. Table 2-3 lists "problematic" components and constituents of C&D waste. These "problematic" wastes are **not** necessarily wastes that are classified as hazardous under RCRA Subtitle C. Some may be "problematic" simply because they are recyclable (e.g., cardboard) or because they are outside the definition of C&D waste as defined by a particular jurisdiction (e.g., garbage).

It is also important to note that wastes that some jurisdictions exclude from C&D landfills or recycling centers are sometimes brought to the C&D disposal areas nonetheless. In some cases these wastes are detected and rejected (Cosper et al., 1993; Lauer, 1993), but in other cases they may not be screened out (Gates et al., 1993), and evidence shows that they are found in C&D landfills (Piasecki et al., 1990).

For discussion purposes, the "problematic" C&D wastes are divided into four categories:

- Excess hazardous materials used in construction and their containers;
- Waste oils and greases and other fluids from machinery;
- Other discrete items; and
- Incidental constituents that are inseparable from bulk C&D wastes (e.g., wood treatment chemicals).

Excess Potentially Hazardous Materials

Construction activities can produce excess "hazardous" materials and "empty" containers containing small quantities of "hazardous" materials. (The source, McGregor et al., 1993, does not define "hazardous," so these wastes may or may not be defined as hazardous under RCRA Subtitle C.) Adhesives and adhesive containers, leftover paint and paint containers, and excess roofing cement and roofing cement cans are a few examples. In some cases construction workers dump leftover paints or solvents on the ground (McGregor et al., 1993). Others may use sawdust, kitty litter, or masking tape to "dry" up empty paint cans and solvent containers (McGregor et al., 1993). "Hazardous" wastes may be disposed of in a dumpster, left at the construction site for a cleanup contractor, self-hauled to a landfill, or returned to the shop[7] (McGregor et al., 1993). Table 2-4 characterizes the 46 pounds of wastes referred to as "hazardous" from construction of a typical 1,850 square-foot single-family residence in Portland, Oregon. Assuming that the total waste weight produced by construction of some 1,810 square-foot houses in Oregon is typical, the 46 pounds would comprise less than 1 percent by weight of the total construction waste (including recycled waste), and less than 10 percent of the landfilled waste.

Machinery Lubricants

Waste oils, greases, and machine fluids are also generated by C&D activities. Examples include brake fluid, form oil, and engine oil (McGregor et al., 1993).

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[7] Based on a survey of twenty builders and subcontractors in Oregon (many of whom are conditionally-exempt small quantity generators (CESQGs)), some CESQGs want more information on how and where to dispose of small quantities of hazardous wastes (McGregor et al., 1993).

TABLE 2-3
"PROBLEMATIC" COMPONENTS OF C&D WASTE
IDENTIFIED BY THE SOURCE DOCUMENTS

Waste Item	Source	Waste Item	Source
CONTAINERS AND EXCESS		lead solder	16
aerosol cans	10	petroleum constituents, leachable from asphalt or roofing tars	16
adhesives	3,6,10	sulfate (in gypsum drywall)	16
caulk	6,8,10	wood, pressure-treated	9
coatings	10	WOOD CONTAMINANTS	
concrete & concrete products	10	Paints and Coatings	
containers with liquids	7	acrylic, acrylic paints	1,4,13,18
driveway sealants	6	lead-based paints	1,4,11,12,14
drums and containers	2	mercury-based paints	12,14
fuel tanks	2,11	pigments in paints containing: lead, arsenic, or chromium	4
joint compound	10	pigments in paints containing: lead, arsenic, barium, cadmium, zinc, mercury, or chromium	16
lacquer thinners	15	water-based paint	13
paints	3,6,7,10,11,15	alkyd	18
pesticides	15	alkyd urea	18
resins	10	polyvinyl acetate	18
roofing cement	10	polyurethane	18
sealers	10	polyesters	18
solvents	10	nitrocellulose	18
MACHINERY LUBRICANTS & FUEL		ethyl cellulose	18
brake fluid	10	butyrate	18
form oil	10	vinyl (PVA/PVC)	18
oils and greases, waste	10	epoxy (reaction products of epichlorohydrin & polyhydric phenols)	18
oil filters	15	melamine	18
INSEPARABLE CONSTITUENTS OF BULK ITEMS		polystyrene	18
asbestos	1,2,3,11,12,14,17	styrene/butadiene	18
formaldehyde (in carpeting)	2	lead	18
lead	1,3	stains	1,4,13
lead flashing	16	varnishes	1,4,13
WOOD CONTAMINANTS		Laminates	

Waste Item	Source	Waste Item	Source
Preservatives		naphthalene	13,16
arsenic & arsenic-containing water-soluble preservatives	1,4,16	melamine/paper	18
chromium & chromium-containing water-soluble preservatives	1,4,16	phenol/paper	18
acid copper chromate (ACC)	18	polyvinyl chloride	18
copper zinc chloride (CZC)	18	polyester	18
arsenates chromated copper arsenate (CCA) ammoniacal copper arsenate (ACA) ammoniacal copper zinc arsenate copperized chromated zinc arsenate (CuCZA)	18 13,18 18 18 18 18	phenol/melamine/paper	18
copper	16	Other Chemical Additives	
creosote	1,4,12,14	ammonia	18
pentachlorophenol	1,12,14,16	borates	18
petroleum distillates, ignitable	12	phosphates	18
wood preservatives	10	polyesters	18
copper naphthenate (in creosote or petroleum)	18	sulfates ammonium sulfate	 18
copper-8-quinolinolate	18	waxes	18
tributyltin oxide	18	OTHER PROBLEMATIC ITEMS	
Adhesives/Resins		appliances or "white goods"	2,3,5
formaldehyde	13,16	batteries	5,7,8,15
glues	4	cardboard	7
phenol-formaldehyde resins	1,4,13,18	carpeting	2,3
urea	13,18	corrugated container board	2
urea formaldehyde resins	1,4,18	CFCs in conditioning systems	17
melamine formaldehyde	18	fiberglass	11
resorcinol formaldehyde	18	furniture	2,3,5
isocyanates	18	garbage	2,5
epoxy	18	mercury-containing switches, bulbs	1,2,15,17
polyvinyl acetate	18	PCBs in transformers and capacitors	1,2,3,15
casein	18	tires	2,5,7
hot melts (containing polyesters, polyamides, or ethylene vinyl acetate)	18	unrecognizable pulverized or shredded waste components	2

TABLE 2-3 (continued)

NOTES:

(1) Identified as hazardous material found within C&D material (Lambert and Domizio, 1993).

(2) Excluded by NYDEC (Piasecki et al., 1990).

(3) High priority substances that should be excluded (Piasecki et al., 1990).

(4) Construction wood contaminants: chemically contained non-wood materials (Federle, 1992).

(5) Materials unacceptable at Kimmins C&D Recycling Facility (Woods 1992 as cited in Cosper et al., 1993).

(6) Materials that may be considered problem materials (Lauer, 1993).

(7) Problem materials (Gates et al., 1993).

(8) Items detected and rejected (Gates et al., 1993).

(9) Potentially toxic material (O'Brien/Palermini, 1993).

(10) Hazardous wastes generated from new construction (McGregor et al., 1993)

(11) Contaminants in construction waste and demolition debris (Apotheker, 1990)

(12) Potential hazards (per the *Vermont Hazardous Waste Regulations*, a material is defined as hazardous if it is corrosive, toxic, flammable, or reactive) (Spencer, 1991).

(13) C&D wood waste that may contain nonhazardous restrictive materials. In this report "restrictive materials" were defined as nonhazardous material present in some types of C&D waste that may restrict end uses for the waste once it is recycled (Spencer, 1991).

(14) An innocent-looking pile of debris may be illegally laced with these (Woods, 1992).

(15) Wastes that are legally considered hazardous according to state and federal regulations have been observed. Materials of concern that have been observed at C&D sites include the following (Hanrahan, 1994).

(16) Hazardous constituents contained in C&D materials (Hanrahan, 1994).

(17) Special and hazardous wastes (SPARK, 1991).

(18) Chemicals in wood products that may affect their use as fuel (ERL, 1992).

TABLE 2-4
"HAZARDOUS" WASTE GENERATED FROM CONSTRUCTION OF A SINGLE-FAMILY RESIDENCE IN PORTLAND, OREGON
(Source: McGregor et al. 1993)

Waste Generated	Quantity (pounds)	Percent of Hazardous Waste (by weight)
Sealers/caulking tubes	15	33
Adhesives	5	11
Resins	1	2
Joint compound	10	21
Aerosol cans	15	33
Total	46	100

Other Discrete Items

Other discrete items may be problematic for a variety of reasons and may be excluded from C&D landfills by state or county regulations. Batteries and fluorescent light bulbs may be excluded because they contain heavy metals (lead and mercury, respectively). Other items, such as cardboard, may be excluded because they are recyclable. As noted above, supposedly "excluded" items are found at C&D landfills, although some items are spotted and rejected during visual inspections (Cosper et al., 1993; Lauer, 1993; Piasecki et al., 1990).

Inseparable Constituents of Bulk Items

Many C&D wastes contain inseparable hazardous constituents. Examples include carpeting that can leach formaldehyde and treated or coated wood and wood products. Extensive information is available on wood treatments and coatings and their constituents. Wood products may leach hazardous constituents into ground water or release them into the air during landfill fires. In some states, fire suppression capabilities are not required at C&D landfills, and C&D landfill fires have occurred in a number of states (Connelly et al., 1991 as cited in Hanrahan, 1994). Table 2-5 provides the information available from the source documents on the concentrations of some of the "problematic" constituents found in wood products. The proportion of the chemical constituent to the wood product ranges from less than 10 parts per million (ppm) for pentachlorophenol in pallets and skids, to 20 percent for creosote in railroad ties, utility poles, pilings, and docks.

SUMMARY

As noted earlier, this report characterizes segments of the C&D waste stream based on information provided in the source documents. Much information on the waste composition is based on generated C&D wastes, which may differ from the composition of landfilled C&D wastes. Additionally, various factors affect the characteristics of C&D waste that were reported, including structure type and size, and the activity being performed.

TABLE 2-5
AMOUNT OF CHEMICAL CONSTITUENTS IN WOOD PRODUCTS
(Source: ERL, 1992)

Wood Product	Chemical Constituent	Amount of Chemical(s) in Wood Product	Note
pallets and skids, (hardwood/softwood)	pentachlorophenol lindane dimethyl phthalate copper-8-quinolinolate copper naphthenate	< 10 ppm	a
pallets, plywood	phenolic resins	2-4%	a
pallets, glued	epoxy	2-4%	
painted wood, lead-based paint	lead	1400-20,000 ppm (before 1950)	b
painted wood, acrylic-based paint	acrylic acid, styrene, vinyl toluene, nitriles	<0.01%	
painted wood, "metallic" pigments	aluminum powder, copper acetate, phenyl mercuric acetate, zinc chromate, titanium dioxide, copper ferrocyanide	<0.01%	
plywood, interior grade	urea formaldehyde (UF) resins	2-4%	c
plywood, exterior grade	phenol formaldehyde (PF) resins	2-4%	c
oriented strandboard	phenol formaldehyde resins, or PF/isocyanate resins	2-4%	
waterboard "Aspenite"	urea formaldehyde resins or phenolic resins	5-15% UF 2.5% PF, 2% wax	d
overlay panels	phenol formaldehyde resins	4-8%, sometimes up to 10%	
plywood/PVC laminate	urea formaldehyde polyvinyl chloride	2.5% UF 10% PVC	
particleboard	urea formaldehyde resins	5-15% UF	d
particleboard with PVC laminate	UF resins with polyvinyl chloride	4.5% UF 10% PVC	
hardboard	phenolic resins	1.5%	
fencing and decks: pressure treated southern pine	CCA or ACA	1-3%	e
fencing and decks: surface treated	CCA or ACA	1-3%	e
utility poles, laminated beams, freshwater pilings, bridge timbers, decking, fencing	pentachlorophenol	1.2-1.5%	f

Wood Product	Chemical Constituent	Amount of Chemical(s) in Wood Product	Note
railroad ties, utility poles	creosote containing 85% PAHs	14-20%	g
freshwater pilings, docks	creosote - coal tar	15-20%	
marine pilings, docks	creosote/chlorpyrifos	15-20%	

a Hardwood pallets are used primarily in the eastern U.S.; softwood and plywood pallets are used primarily in the western U.S.

b Lead level is highly dependent on the age of the paint; before 1950 lead comprised as much as 50% of the paint film. Legislation in 1976 reduced standard to 0.06% by weight.

c Plywood may be surface-coated with fire retardants, preservatives and insecticides, or pressure-treated with CCA.

d May be sealed with polyurethane or other sealant to prevent offgassing of formaldehyde.

e Dominant wood preservative; actual levels will be lower due to evaporation or leaching after treatment.

f Restricted use due to industry change and concern over dioxin linkage; not permitted for residential uses.

g Losses after treatment estimated to be 20-50% over 10-25 years; not recommended for residential use.

Overall, C&D waste streams are comprised mainly of wood products, asphalt, drywall, and masonry. Other notable components include metals, plastics, earth, shingles, and insulation. Most of the source documents did not provide information on the percentage of C&D waste that is "hazardous." Those that did indicated that "hazardous" waste comprised a small percentage of the total C&D waste stream (e.g., 0.4 percent of construction waste in one county in North Carolina). The source documents did not define "hazardous" or other "problematic" wastes as wastes that are classified as hazardous under RCRA Subtitle C.

The source documents did note that although C&D wastes have traditionally been considered inert and harmless, they have become an issue of concern in the 1990s. This is largely because some C&D wastes that were previously considered harmless are now considered to be "toxic" or to contain "hazardous" materials, such as wood that is coated with lead paint (Piasecki et al., 1990; Lambert and Domizio, 1993). "Problematic" wastes cited by three or more of the reports or articles in the source documents are: adhesives, caulk, paint, wood preservatives, formaldehyde resins, stains and varnishes, appliances, batteries, mercury-containing switches and lights, PCB-containing transformers and capacitors. Again, these "problematic" wastes may or may not qualify as hazardous wastes under RCRA Subtitle C. More attention has also focused on C&D landfills because they may be used to dump hazardous wastes illegally (Piasecki et al., 1990; Lambert and Domizio, 1993).

REFERENCES

Hanrahan, Pegeen. *Construction and Demolition Debris Disposal Issues: An Alachua County Perspective*. Alachua County Environmental Protection Department. May 1994.

Lambert, Geri, and Domizio, Linda. *Construction and Demolition Waste Disposal: Management Problems and Alternative Solutions*. Massachusetts Department of Environmental Protection. February 1993.

National Association of Demolition Contractors. *C&D Waste Characterization Database: Volume 1 - Compilation of Report Excerpts*. Prepared by Gershman, Brickner & Bratton, Inc. Falls Church, VA. February 18, 1994. Includes excerpts from the following reports:

> Davidson, Thomas A. (Massachusetts Institute of Technology). *Workshop on the Potential for Recycling Demolition Debris*. Prepared for the National Science Foundation. June 22, 1978.
>
> Wilson, David G., Davidson, Thomas A., and Ng, Herbert T.S. *Demolition Wastes: Data Collection and Separation Studies*. Prepared for the National Science Foundation. December 1979.
>
> Thomé-Kozmiensky, Karl J. (EF-Verlag für Energie- und Umwelttechnik GmbH). *Recycling International* (Volume 3). 1986.
>
> Piasecki, Bruce W., Ray, Joel, and Golden, Patrick (American Hazard Control Group). *Managing Construction and Demolition Debris: Trends, Problems and Answers*. Prepared for the Associate Building Contractors of the Triple Cities, Inc. and General Building Contractors of New York State. March 1990.
>
> C.T. Donovan Associates, Inc. (Burlington, Vermont). *Recycling Construction and Demolition Waste in Vermont: Final Report*. Prepared for the Vermont Agency of Natural Resources, Recycling and Resource Conservation Section, Waterbury, Vermont. December 1990.
>
> SPARK Construction Waste Sub-Committee of the Science Council of British Columbia. *Construction Waste Management Report*. Prepared for the Construction Sector Committee of the Science Council's Strategic Planning for Applied Research Knowledge in conjunction with the National Research Council's Industrial Research Assistance Program. January 1991.
>
> Greater Toronto Home Builders' Association (THBA). *Making a Molehill out of a Mountain II*. June 1991.
>
> Donohue/JRP Asia Pacific Ltd. (in association with Gershman, Brickner & Bratton, Inc.). *Study on Recycling of Construction Waste Received at Landfills: Final Report*. Prepared for the Hong Kong Government Environmental Protection Department. September 1991.
>
> Federle, Mark O. (Department of Civil and Construction Engineering). *Analysis of Building Construction Recycling Efforts in Iowa*. Prepared for the Engineering Research Institute at Iowa State University. 1992.
>
> European Demolition Association (The Netherlands). *Demolition and Construction Debris*. Circa 1992.
>
> Mac Viro Consultants, Inc. (Ontario). *Preliminary Study of Construction and Demolition Waste Diversion Constraints and Opportunities*. Prepared for the Ontario Ministry of the Environment. March 1992.
>
> Environmental Risk Limited (ERL). *Wood Products in the Waste Stream Characterization and Combustion Emissions: Volume 1*. November 1992.
>
> C.T. Donovan Associates, Inc. *Recycling Construction and Demolition Waste in Rhode Island*. Prepared for Rhode Island Governor's Office of Housing, Energy and Intergovernmental Relations. December 1992.

Cosper, Stephen D., Hallenbeck, William H., Brenniman, Gary R. *Construction and Demolition Waste: Generation, Regulation, Practices, Processing, and Policies*. Prepared for the Illinois Department of Energy and Natural Resources. January 1993.

Lauer, Pamela W. (Innovative Waste Management). *Construction Materials Recycling Guidebook*. Prepared for the Metropolitan Council of the Twin Cities Area. March 1993.

Gates, Betsy, Latham, Cathy, Nelson, Wayne, and Washington, Darrell. *Non-Mixed Municipal Solid Waste Composition and Volume Metropolitan Area 1990-1991*. Prepared for the Minnesota Pollution Control Agency Metropolitan Council. Spring 1993.

O'Brien & Associates/Palermini & Associates. *Residential Remodeling Waste Reduction Demonstration Project*. June 1993.

Triangle J Council of Governments. *Construction and Demolition Debris Reduction and Recycling: A Regional Approach*. Prepared for the Office of Waste Reduction, North Carolina Department of Environment, Health, and Natural Resources. June 1993.

Palermini & Associates (Portland, Oregon). *Construction Industry Recycling Project: Final Report*. Prepared for the Portland METRO Solid Waste Department. July 1993.

McGregor, Mark, Washburn, Howard, and Palermini, Debbi. *Characterization of Construction Site Waste*. Presented to the Portland METRO Solid Waste Department. July 1993.

Gershman, Brickner & Bratton, Inc. (Falls Church, Virginia). What's in a Building? *Demolition Age*. October 1993.

National Association of Demolition Contractors. *C&D Waste Characterization Database: Volume 1 - Compilation of Articles*. Prepared by Gershman, Brickner & Bratton, Inc. Falls Church, VA. February 18, 1994. Includes the following articles:

Spencer, Robert. Recycling Opportunities for Demolition Debris. *Biocycle*. November 1989.

Apotheker, Steve. Construction and Demolition Debris -- The Invisible Waste Stream. *Resource Recycling*. December 1990.

Spencer, Robert. Taking Control of C&D Debris. *Biocycle*. July 1991.

Lambert, Geri (Massachusetts Department of Environmental Protection). *Construction and Demolition Waste Disposal: Management Problems and Alternative Solutions*. Prepared for the Northeast Waste Management Official's Association. October 1991.

Woods, Randy. C&D Debris: A Crisis is Building. *Waste Age*. January 1992.

Rebeiz, K.S. Recycling Plastics in the Construction Industry. *Waste Age*. February 1992.

Lee, Benjamin. New-Style MRFs Recycling Construction and Demolition Waste. *Solid Waste & Power*. October 1992.

Schlauder, Richard M., and Brickner, Robert H. (Gershman, Brickner & Bratton, Inc.). Setting Up for Recovery of Construction and Demolition Waste. *Solid Waste & Power*. January/February 1993.

CHAPTER 3
LEACHATE QUALITY ANALYSIS

This chapter summarizes available information on construction and demolition (C&D) debris landfill leachate. The methodology is discussed first, followed by the results of the analysis.

METHODOLOGY

This analysis is based on construction and demolition debris landfill leachate sampling data presented in two documents assembled by Gershman, Brickner & Bratton, Inc. (GBB) for the National Association of Demolition Contractors (NADC). One document, "C&D Waste Landfills, Leachate Quality Data, Volume 1, Specific State-by-State Responses," presents the results of GBB's efforts to obtain leachate data from state officials. The second document, "C&D Waste Landfills, Leachate Quality Data, Volume 2, Copies of Reports, Articles, and Other Related Data," is a compilation of several reports germane to C&D landfill leachate quality.

In addition to the information compiled by NADC, other studies of C&D debris landfill leachate have been performed. Selected studies are reviewed, and the results compared to this study, in Attachment 3-A.

The methodology for using NADC's data as a basis for characterizing C&D landfill leachate quality comprised the following steps:

- Selecting C&D landfills to include in the analysis;
- Developing a C&D landfill leachate database;
- Compiling parameter-specific regulatory and health-based "benchmarks" to use as a basis for screening potential risks;
- Screening out parameters that were never detected in C&D landfill leachate, or that never exceeded the benchmark;
- Calculating median values (using only detected values) for each parameter detected at a concentration above the benchmark; and
- Calculating the ratio of the parameters' median concentrations to the benchmarks.

Each step is discussed below.

Selecting C&D Landfills

The two reports prepared for NADC by GBB present leachate sampling data for numerous landfills in many states. While much of the information is landfill-specific, some is presented in different formats such as average parameter concentrations across landfills in a given state, or as ranges of concentrations across groups of landfills. To develop the leachate database for this report, only landfill-specific sampling data were used. Thus, this report is based on leachate sampling data for 21 C&D landfills, listed in Table 3-1. For ease in reviewing the database in Attachment 3-B, the abbreviated database code for each landfill is also presented in Table 3-1.

TABLE 3-1
LANDFILLS FROM WHICH LEACHATE DATA WERE EXTRACTED FOR ANALYSIS

Landfill Name	Database Reference
CDI, Colorado	CO
Deep River Bulky Waste Landfill, Connecticut	CT-1
Guilford Bulky Waste Landfill, Connecticut	CT-2
Groton Bulky Waste Landfill, Connecticut	CT-3
Glastonbury Bulky Waste Landfill, Connecticut	CT-4
ITI Trucking Terminal site, Connecticut	CT-5
D & M site, Connecticut	CT-6
Armetta Property, Connecticut	CT-7
Iowa #4 site, Iowa	IA-1
Iowa #5 site, Iowa	IA-2
Brandywine/Cross Trails Rubble Landfill, Maryland	MD
Unnamed Kentucky site from 1991 WMNA study, Kentucky	KY
Unnamed Massachusetts site from 1991 WMNA study, Massachusetts	MA
Unnamed Michigan site from 1991 WMNA study, Michigan	MI
SKB Rich Valley Waste Management Facility, Minnesota	MN
110 Sand & Gravel site, New York	NY-1
Blydenburg Cleanfill, New York	NY-2
South Carolina Landfill #1, South Carolina	SC
Sanifill, Inc. site (high in 3-site range), Texas	TX HI
Sanifill, Inc. site (low in 3-site range), Texas	TX LO
Mt. Olivet Landfill, Washington	WA

Developing a C&D Landfill Leachate Database

Leachate sampling data for the 21 landfills were entered into a database, Attachment 3-B. The database contains sampling data for a total of 305 parameters analyzed for at least once. A blank entry in the database indicates that the parameter was not sampled for at that landfill. In many cases, a parameter was sampled for but not detected at a landfill. Non-detects were handled in one of two ways:

- If a detection limit (say, "X") was given by GBB, "<X" was entered in the database.
- If no detection limit was given, "ND" was entered in the database.

As data were taken from many different landfills (and thus many different sampling laboratories), there were cases in which different names were used to address the same parameter. The differing nomenclatures used by different landfills were reconciled so that all synonyms were joined into one parameter row. In addition, some samples were identified as "total" and others as "dissolved." To be conservative, the "total" values were entered into the database.

Compiling Regulatory and Health-based Benchmarks

The next step was to identify parameter-specific benchmarks, or concern levels, to use as a basis for determining whether the parameter concentrations in leachate are high enough to pose potential risk. Safe Drinking Water Act National Primary and Secondary Drinking Water Standards were used as the benchmarks if these were available; these are referred to in the remainder of this report as Maximum Contaminant Levels (MCLs) or Secondary Maximum Contaminant Levels (SMCLs).[8] Both are enforceable drinking water standards. While MCLs are health-based, SMCLs are based on other factors such as aesthetics. Both MCLs and SMCLs are also based on the availability of treatment technologies and other factors such as availability of data and analytical methods.

For parameters without MCLs or SMCLs, health-based benchmarks for a leachate ingestion scenario were compiled as follows:

- Reference doses (RfDs) were compiled for non-carcinogens. EPA calculates RfDs by dividing animal toxicity values by suitable scaling or uncertainty and modifying factors. The RfDs used in this study were taken from EPA's Integrated Risk Information System (IRIS) or Health Effects Assessment Summary Tables (HEAST). The RfDs (mg/kg-day) were then converted to benchmark concentrations in drinking water using EPA's standard exposure assumptions (daily intake of two liters per day, average body weight of 70 kg, and exposure duration of 365 days per year over 70 years).

- Risk-specific doses (RSDs) were calculated for carcinogens based on cancer slope factors (CSFs). A CSF is a measure of the carcinogenic potency of low doses of carcinogens. CSFs represent the upper-bound confidence limit estimate of the excess cancer risk for individuals experiencing a given exposure over a lifetime. EPA calculates CSFs from dose-response curves, which are based on human epidemiological and/or animal bioassay data. For this study, CSFs given in IRIS or HEAST were used, and the standard exposure assumptions listed above, to calculate the drinking water concentration that would correspond to an excess lifetime cancer risk of 10^{-6}.

Many of the parameters detected in C&D landfill leachate have not been studied sufficiently to allow an RfD or a CSF to be developed. For these parameters, no benchmarks were available for this study.

Screening Out Parameters

In this step, the maximum observed value of each parameter was simply compared to its regulatory or health-based benchmark. Parameters that were never observed in C&D landfill leachate at levels above their respective benchmarks were screened out, the rationale being that if the undiluted leachate is "safe to drink," no further analysis is needed. Also excluded from further consideration were parameters that were sampled for but never detected in landfill leachate.

Calculating Median Leachate Concentrations

For each parameter with at least one exceedance over the benchmark, the median leachate concentration was calculated across all landfills at which the parameter was sampled. Medians, rather than averages, were calculated in order to reduce the effect of single, anomalous values.

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[8]Where available, existing MCLs or SMCLs were used; otherwise, proposed values were used.

When calculating the median value for each parameter, the median value for each landfill was first calculated, and then the median value across all landfills was calculated. For example, if parameter X was sampled once at Landfill A, once at Landfill B, and six times or at six locations at Landfill C, the median concentration was calculated based on the Landfill A sample, the Landfill B sample, and the median among the Landfill C samples. Thus, each landfill is represented only once for each parameter, and each landfill is weighted equally.

Due to anomalies and inconsistencies among the sampling equipment used at different times and at different landfills, non-detects were not considered in determining median values. In other words, for those parameters for which a median was calculated, the non-detects were discarded before calculating both individual landfill concentration medians and medians across all landfills. Thus, the median leachate concentrations calculated for this analysis represent the median among the detected values, rather than the median among all values. The median concentration among all values would in most cases have been lower than those calculated here.

Comparing Medians to Benchmarks

The median value for each parameter was then compared to the benchmark for that parameter, if one was available. The results are expressed as the ratio of the median leachate concentration to the benchmark.

RESULTS

As discussed above, the leachate database contains sampling data for 305 parameters analyzed for at one or more of 21 construction and demolition landfills. Of these 305 parameters, 93 were detected at least once. The other 212 parameters, almost all organics, were never detected, and are listed in Table 3-2; many of them were sampled for at only one or two landfills, and often only once or twice at those sites.

All 93 parameters that were detected at least once are listed in Table 3-3, along with the number of landfills at which the parameter was sampled, the number of landfills at which the parameter was detected, the maximum and minimum values for each parameter (here, including non-detects), and the relevant benchmark, if available. Maximum concentrations above the benchmark are shaded. For pH, the minimum pH level below the benchmark range is shaded.

Table 3-4 focuses on the parameters whose maximum concentrations exceeded their benchmarks (i.e., the parameters shaded in Table 3-3). For each parameter, Table 3-4 repeats the number of landfills at which the parameter was sampled and detected, but also shows the number of landfills at which the benchmark was exceeded. Table 3-4 also provides the median value of each parameter across all landfills, each parameter's benchmark, and the ratio of the medians to benchmarks. Again, due to anomalies and inconsistencies among sampling equipment, non-detects were not considered in determining median values.

The results are discussed below.

TABLE 3-2
PARAMETERS ANALYZED FOR BUT NEVER DETECTED

ORGANICS			
Acetonitrile	m-Cresol	Endosulfan II	N'Nitroso-di-n-propylamine
Acetophenone	Cumene	Endrin	N-Nitrosomorpholine
2-Acetylaminofluorene	2,4-D	Endrin aldehyde	N-Nitrosopiperidine
Acrolein	4,4-DDD	Endrin ketone	N'Nitrosopyrolidine
Acrylonitrile	4,4-DDE	Ethyl ether	5-Nitro-o-toluidine
Aldrin	4,4,4-DDT	Ethylmethacrylate	PeCDD
alpha-Chlordane	delta-BHC	Ethyl methane sulfonate	PeCDF
alpha-Endosulfan	Diallate	Ethyl parathion	Pentachlorobenzene
4-Aminobiphenyl	Dibenzo(a,h)anthracene	Famphur	Pentachloronitrobenzene
Aniline	Dibenzofuran	Fluoranthene	Pentachlorophenol
Anthracene	Dibromochloromethane	Fluorene	Pentachlorothane
Aramite	1,2-Dibromo-d-chloropropane	Heptachlor	Phenacetin
Aroclor/PCB 1016	Dibromomethane	Heptachlor epoxide	Phenanthrene
Aroclor/PCB 1221	1,2-Dibromoethane	Hexachlorobenzene	Phenolphthalein Alkalinity
Aroclor/PCB 1232	Di-a-butyl phthalate	Hexachlorobutadiene	p-Phenylemediamine
Aroclor/PCB 1242	Dichloroacetonitrile	Hexachlorocyclopentadiene	Phorate
Aroclor/PCB 1248	1,2-Dichlorobenzene	Hexachloroethane	2-Picoline
Aroclor/PCB 1254	1,3-Dichlorobenzene	Hexachlorophene	Pronamide
Aroclor/PCB 1260	1,4-Dichlorobenzene	Hexachloropropene	Propionitrile, Ethyl cyanide
Benzo-a-anthracene	3-3-Dichlorobenzidine	Hx-CDD	Pyrene
Benzo-a-pyrene	trans-1,4-Dichloro-2-butene	HxCDF	Pyridine
Benzo-b-fluoranthene	Dichlorodifluoromethane	Indeno(1,2,3-cd)pyrene	Safrole
Benzo(k)fluoranthene	1,2-Dichloroethene	Iodomethane	Silvex, 2,4,5-TP
Benzo-g,h-perylene	1,1-Dichloroethene	Isobutanol	Sulfotepp
Benzo-g,h,i-perylene	Dichlorofluoromethane	Isodrin	TCDD
Benzo-k-perylene	2,4-Dichlorophenol	Isophorone	2,3,7,8-TCDD
Benzyl alcohol	2,6-Dichlorophenol	2-Isophorone	TCDF
beta-BHC	trans-1,2-Dichloropropane	Isosafrole	1,2,4,5-Tetrachlorobenzene
beta-Endosulfan	1,2-Dichloropropane	Kepone	1,1,1,2-Tetrachloroethane
Bis(2-chloroethoxy)methane	1,3-Dichloropropane	Lindane	1,1,2,2-Tetrachloroethane
Bis(2-chloroethyl)ether	2,2-Dichloropropane	Methacryonitrile	2,3,4,6-Tetrachlorophenol
Bis(2-chloroisopropyl)ether	trans-1,3-Dichloropropene	Methapyrilene	Tetrahydrofuran
Bis(2-chloro-1-methyl)ether	1,1-Dichloropropene	Methoxychlor	Thionazin
Bis(2-ethylhexyl)phthalate	2,3-Dichloro-1-propene	3-Methylchloanthrene	o-Toluidine
Bromodichloromethane	cis-1,3-Dichloropropene	Methyl methacrylate	Toxaphene
Bromoform	p-(Dimethylamino)azobenzene	Methyl methane sulfonate	1,2,4-Trichlorobenzene
Bromomethane	Dimethaote	2-Methylnaphthalene	1,1,1-Trichloroethane
4-Bromophenyl-phenylether	7/12-Dimethylbenz(a)anthracene	Methyl parathion; Parathion mehtyl	1,1,2-Trichloroethane
Butyl benzyl phthalate	3,3-Dimethylbenzidine	(3&4)-Methylphenol	2,4,5-Trichlorophenol
Carbon tetrachloride	Dimethylphenethylamine	1,4-Naphthoquinone	2,4,6-Trichlorophenol
Carbonate	2,4-Dimethylphenol	1-Naphthylamine	1,2,3-Trichloropropane
Chlordane	Dimethyl phthalate	2-Naphthylamine	1,1,2-Trichlorotrifluoroethane
4-Chloroaniline	1,3-Dinitrobenzene	2-Nitroaniline	o,o,o-Triethyl phosphorothiole
Chlorobenzene	4,6-Dinitro-2-methylphenol	3-Nitroaniline	sym-Trinitrobenzene
Chlorobenzilate	2,4-Dinitrophenol	4-Nitroaniline	Vinyl acetate
2-Chloro-1,3-butadiene, Chloroprene	2,4-Dinitrotoluene	Nitrobenzene	Vinyl chloride
Chlorodibromomethane	2,6-Dinitrotoluene	o-Nitrophenol	INORGANICS
2-Chloroethyl Vinyl Ether	Dinoseb, DNBP	p-Nitrophenol	Antimony
4-Chloro-3-methylphenol	Di-a-octyl phthalate	4-Nitroquininoline-1-oxide	Thallium
4-Chlorophenyl phenyl ether	Di-n-octyl phthalate	N-Nitrosodi-a-butylamine	Tin
2-Chloronaphthalene	1,4-Diomene	N-Nitrosodiethylamine	CONVENTIONAL PARAMETER
2-Chlorophenol	Diphenylamine	N-Nitrosodimethylamine	Total Settled Solids
3-Chloropropene, Allyl Chloride	Endosulfan sulfate	N-Nitrosodimethylethylamine	
Chrysene	Endosulfan I	N-Nitrosodiphenylamine	

TABLE 3-3
FREQUENCY OF DETECTION, RANGE, AND BENCHMARK FOR DETECTED PARAMETERS
(Concentrations in ug/l)

TABLE 3-3. FREQUENCY OF DETECTION, RANGE, AND BENCHMARK FOR DETECTED PARAMETERS (Concentrations in ug/l)

PARAMETER	# LANDFILLS SAMPLED	# LANDFILLS DETECTED	MAXIMUM	MINIMUM	BENCHMARK	
					VALUE	**SOURCE**
ORGANICS						
Acenaphthene	7	1	3	ND	2000	RfD
Acetone	6	4	5100	ND	4000	RfD
alpha-BHC	6	1	0.12	ND	0.006	10^-6 RSD
Benzene	9	2	2.7	ND	5	MCL
Benzoic acid	4	2	910	ND	--	--
Carbon disulfide	5	2	15	ND	4000	RfD
Chloroethane	9	2	353	ND	--	--
Chloroform	9	1	3	ND	100	MCL
Chloromethane	9	2	43	ND	--	--
cis-1,2-Dichloroethane	2	1	1.4	ND	--	--
1,2-Dichloroethane	9	3	26	ND	5	MCL
1,1-Dichloroethane	9	3	6.2	ND	4000	RfD
1,1-Dichloroethene	9	1	3	ND	7	MCL
trans-1,2-Dichloroethene	4	1	4	ND	100	MCL
Dieldrin	6	1	0.065	ND	0.002	10^-6 RSD
Diethyl phthalate	7	1	16	ND	30000	RfD
Disulfoton	3	1	0.96	ND	1	RfD
Di-n-butyl phthalate	4	1	16	ND	4000	RfD
Ethylbenzene	9	5	18	ND	700	MCL
2-Hexanone (methyl butyl ketone)	5	1	4.8	ND	--	--
Methyl ethyl ketone (MEK)	6	2	2500	ND	20000	RfD
Methylene chloride	9	3	60	ND	5	MCL
2-Methylphenol (o-cresol)	7	2	130	ND	--	--
4-Methyl-2-pentanone	6	2	250	ND	--	--
4-Methylphenol (p-cresol)	5	4	5700	ND	--	--
Naphthalene	7	2	63	ND	1000	RfD
Phenol	8	5	2990	ND	20000	RfD
Styrene	5	1	1.1	ND	100	MCL
Tetrachloroethene	9	1	4.8	ND	5	MCL
Toluene	9	4	240	ND	1000	MCL
Trichloroethene	9	3	20	ND	5	MCL
Trichlorofluoromethane	5	2	20	ND	10000	RfD
2,4,5-T, 2,4,5-Trichlorophenoxyacetic acid	4	2	0.53	ND	50	MCL

TABLE 3-3 (cont.)
FREQUENCY OF DETECTION, RANGE, AND BENCHMARK FOR DETECTED PARAMETERS
(Concentrations in ug/l)

TABLE 3-3. FREQUENCY OF DETECTION, RANGE, AND BENCHMARK FOR DETECTED PARAMETERS (Concentrations in ug/l)

PARAMETER	# LANDFILLS SAMPLED	# LANDFILLS DETECTED	MAXIMUM	MINIMUM	BENCHMARK VALUE	BENCHMARK SOURCE
Xylene (total)	8	4	85	ND	10000	MCL
INORGANICS						
Aluminum	1	1	6350	ND	50-200	SMCL
Arsenic	16	12	120	ND	50	MCL
Barium	13	13	8000	ND	2000	MCL
Beryllium	5	1	2.1	ND	4	MCL
Boron	2	2	3900	1400	--	--
Cadmium	19	14	2050	ND	5	MCL
Chromium	16	9	250	ND	100	MCL
Hexavalent Chromium	5	2	4920	ND	--	--
Cobalt	4	1	60.9	ND	--	--
Copper	18	14	620	ND	1000	SMCL
Cyanide	12	9	340	ND	200	MCL
Cyanides (total)	6	4	38	ND	--	--
Iron	20	20	172000	ND	300	SMCL
Filtered Iron	2	2	11000	240	--	--
Lead	18	15	2130	ND	15	Action Level
Magnesium	7	7	460000	ND	--	--
Mercury	15	4	9	ND	2	MCL
Nickel	12	7	170	ND	100	MCL
Potassium	9	9	618000	ND	--	--
Selenium	14	1	5	ND	50	MCL
Silver	12	2	30	ND	100	SMCL
Vanadium	4	2	96	ND	200	RfD
Zinc	15	15	8630	ND	5000	SMCL
CONVENTIONAL PARAMETERS						
Alkalinity	13	13	6520000	ND	--	--
Ammonia	3	3	480000	ND	--	--
Ammonia, Nitrogen	14	13	184000	ND	--	--
Bicarbonate	2	2	7950000	2090000	--	--
Biological Oxygen Demand (BOD) (5-day)	14	13	320000	ND	--	--
Biological Oxygen Demand (BOD) (20-day)	5	5	83000	5000	--	--

TABLE 3-3. FREQUENCY OF DETECTION, RANGE, AND BENCHMARK FOR DETECTED PARAMETERS (Concentrations in ug/l)						
					BENCHMARK	
PARAMETER	# LANDFILLS SAMPLED	# LANDFILLS DETECTED	MAXIMUM	MINIMUM	**VALUE**	**SOURCE**
Calcium	7	7	600000	ND	--	--
Chemical Oxygen Demand (COD)	18	17	11200000	ND	--	--
Chlorides	20	20	2400000	ND	250000	SMCL
Dissolved Oxygen (%)	1	1	4.8	0.3	--	--
Fluoride	3	2	5000	ND	2000	SMCL
Hardness by Calculation	10	10	2420000	150000	--	--
Manganese	14	14	258000	ND	50	SMCL
Nitrate	14	10	13000	ND	10000	MCL
Nitrate/Nitrite	1	1	290	290	10000	MCL
Nitrite	10	6	47	ND	1000	MCL
Organic Nitrogen	7	7	11000	70	--	--
Total Kjeldahl Nitrogen	3	3	300000	3730	--	--
Oil and Grease	7	6	50000	ND	--	--
Oxidation-Reduction Potential	2	2	580	ND	--	--
pH	18	18	8	6.2	6.5-8.5	SMCL
Total Phenolics	4	3	4900	ND	--	--
Phosphate	2	1	3900	ND	--	--
Phosphorus	5	4	3890	ND	--	--
Total Phosphorus	3	3	1600	100	--	--
Sodium	12	12	1510000	ND	--	--
Solids, volatile	2	2	380000	170000	--	--
Specific Conductance (h)	12	12	25000	220	--	--
Sulfates	16	14	2700000	ND	250000	SMCL
Surfactants	1	1	1100	ND	--	--
Tannin	1	1	120000	120000	--	--
Total Dissolved Solids	18	17	8400000	ND	500000	SMCL
Total Organic Carbon	7	7	1080000	ND	--	--
Total Organic Halogens	3	3	910	740	--	--
Total Suspended Solids	16	15	43000000	ND	--	--
Turbidity (NTU)	3	3	630	ND	--	--

ND = Not Detected
RfD = Reference Dose
10^-6 RSD = 10^-6 Risk-specific Dose

TABLE 3-4
FREQUENCY OF DETECTION ABOVE BENCHMARK AND COMPARISON OF MEDIANS TO BENCHMARKS
(Concentrations in ug/l)

PARAMETER	# LANDFILLS SAMPLED	# LANDFILLS DETECTED	# LANDFILLS > BENCHMARK	MEDIAN*	BENCHMARK		MEDIAN/ BENCHMARK
					VALUE	SOURC	
ORGANICS							
Acetone	6	4	1	230	4000	RfD	0.058
alpha-BHC	6	1	1	0.12	0.006	10^-6	20
1,2-Dichloroethane	9	3	3	19	5	MCL	3.8
Dieldrin	6	1	1	0.065	0.002	10^-6	33
Methylene chloride	9	4	3	15.2	5	MCL	3
Trichloroethene	9	3	1	3.2	5	MCL	0.6
INORGANICS							
Aluminum	1	1	1	245	50-200	SMCL	4.9 (1.2 Min)
Arsenic	16	12	3	19.5	50	MCL	0.39
Barium	13	13	1	340	2000	MCL	0.17
Cadmium	19	14	12	10.5	5	MCL	2.1
Chromium	16	9	3	45	100	MCL	0.45
Cyanide	12	9	2	24.5	200	MCL	0.12
Iron	20	20	19	11003	300	SMCL	37
Lead	18	15	13	55	15	Action	3.7
Mercury	15	4	1	0.5	2	MCL	0.25
Nickel	12	7	2	50	100	MCL	0.5
Zinc	15	15	1	135	5000	SMCL	0.027
CONVENTIONAL							
Chlorides	20	20	4	110000	250000	SMCL	0.44
Fluoride	3	2	1	2700	2000	SMCL	1.4
Manganese	14	14	13	2925	50	SMCL	59
Nitrate	14	10	1	520	10000	MCL	0.052
Sulfates	16	14	6	119000	250000	SMCL	0.48
Total Dissolved	18	17	15	1770000	500000	SMCL	3.5

* Medians of detected values only

Organics

The frequency of detection of organics was generally low compared to metals and conventional parameters. Of the 34 organics listed in Table 3-3, only 8 were detected at half or more of the landfills at which they were sampled: acetone, benzoic acid, cis-1,2-dichloroethane, ethylbenzene, 4-methylphenol, phenol, 2,4,5-T, and xylenes. Six organics exceeded their respective benchmarks at least once, including acetone, alpha-BHC, 1,2-dichloroethane, dieldrin, methylene chloride, and trichloroethene.

Of the six organic constituents found above their benchmarks, Table 3-4 shows that four (acetone, alpha-BHC, dieldrin, and trichloroethene) were detected above their benchmarks at only one landfill. While this is noteworthy, these constituents are not subject to further assessment here because their exceedances cannot be considered representative.

The median leachate concentrations (among the detected values) of both of the remaining constituents -- 1,2-dichloroethane and methylene chloride -- exceed their benchmarks. Neither of them exceeds its benchmark by a factor of 10 or more, however. Assuming that a 100-fold reduction in concentration is achieved between the leachate and a downgradient drinking water well (as would be likely, based on the dilution attenuation factor [DAF] of 100 developed for the Toxicity Characteristic rulemaking), the concentrations would fall well below the benchmarks at the point of exposure. Even if a smaller DAF of 10 is applied (as may be applicable at a monitoring well located closer to the landfill), neither constituent would exceed its benchmark. Again, these medians only account for detected values. Had the non-detects been included, the median concentrations of all but one of the organics would have been in the non-detect range.

Inorganics

Most of the inorganics listed in Table 3-3 were detected at half or more of the landfills at which they were sampled: aluminum, arsenic, barium, boron, cadmium, chromium, copper, cyanide, iron, lead, magnesium, nickel, potassium, vanadium, and zinc. The 11 constituents exceeding their benchmarks included aluminum, arsenic, barium, cadmium, chromium, cyanide, iron, lead, mercury, nickel, and zinc.

As shown in Table 3-4, seven inorganics were detected above their benchmarks at more than one landfill: arsenic, cadmium, chromium, cyanide, iron, lead, and nickel. The median leachate concentrations exceed the benchmarks for only three of these inorganics, however: cadmium, iron, and lead. None of the median leachate concentrations exceeds its benchmark by a factor of 100 or more, and iron is the only constituent whose median exceeds its benchmark by a factor greater than 10. Iron was detected at all 20 landfills at which it was sampled, and was detected above its benchmark at least once at 19 of them. Excluding the few non-detects, the median concentration of iron in leachate is 37 times higher than its drinking water standard, which is a secondary MCL based on taste.

Conventional Parameters

As would be expected, all of the conventional parameters were detected at most, and often all, of the sites at which they were analyzed. The conventional parameters with maximum concentrations exceeding their respective benchmarks included chlorides, fluoride, manganese, nitrate, sulfates, and total dissolved solids (TDS). Only chlorides, manganese, sulfates, and TDS exceeded their benchmarks at more than one landfill. Of these four parameters, only manganese and TDS have medians above the benchmark. The median level of manganese exceeds its SMCL (by 59 times), while the median level of TDS exceeds its SMCL by over three times. In addition to these parameters, more than one landfill had a measured pH value outside of the range of the SMCL for pH.

SUMMARY

Leachate sampling data for 305 parameters sampled for at one or more of 21 C&D landfills were compiled into a database, shown in Attachment 3-B. Of these 305 parameters, 93 were detected at least once. Almost all of the

212 parameters that were never detected were organics; most of the inorganic and conventional parameters sampled for were detected one or more times.

Of the 93 parameters detected in C&D landfill leachate, 24 had at least one measured value above the regulatory or health-based benchmark.[9] For each of the parameters exceeding benchmarks (except pH), the median leachate concentration was calculated and compared to its benchmark. Due to anomalies and inconsistencies among the sampling equipment used at different times and at different landfills, non-detects were not considered in determining median values. Thus, the median leachate concentrations represent the medians among the detected values, rather than the median among all values. The median concentrations among all values would in most cases have been lower than those calculated here.

Based on (1) the number of landfills at which the benchmark was exceeded and (2) a comparison between the median detected concentration and the benchmark, seven parameters emerge as being potentially problematic. The list of these seven parameters, shown below, was developed by eliminating from the original list of 24 parameters (1) any parameter that was detected at only one landfill (this was determined to be not representative) and (2) any parameter whose median leachate concentration did not exceed its benchmark.

<u>organics</u>

- 1,2-dichloroethane
- methylene chloride

<u>inorganics</u>

- cadmium
- iron
- lead

<u>conventional parameters</u>

- manganese
- total dissolved solids (TDS)

For three of the seven parameters listed above (iron, manganese, and TDS), the benchmarks are secondary MCLs (SMCLs), which are set to protect water supplies for aesthetic reasons (e.g., taste) rather than for health-based reasons. None of the remaining four parameters exceeds its benchmark by a factor of 10 or more, indicating that concentrations in ground water where ground-water monitoring or drinking water wells may be located are likely to fall below the health-based benchmarks.

CAVEATS AND LIMITATIONS

All conclusions made from the data presented in this report should be tempered by the following weaknesses in the samples used to calculate some of the leachate characteristics:

- First, the sample size is much smaller than the universe of C&D landfills nationwide. The 21 landfills represented in this report comprise just over one percent of the approximately 1,800 C&D landfills in the United States. Thus, the representativeness of the sample is questionable.

- Many of the parameters discussed in this report were only sampled at one or two landfills, and such data cannot be considered representative of 1,800 landfills.

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[9] In the case of pH, the "exceedances" were actually pH values <u>below</u> the regulatory range.

- The medians calculated in this report do not account for non-detects. Although the medians would be more meaningful if the non-detects could be factored in, this report attempts to capture the impact of the non-detects by presenting both the frequency of detection and the frequency of detection above benchmarks.

- Some landfills do not characterize (or give an incomplete characterization of) the waste at their sites. Thus, in some cases, the respondents' assertions that their landfills are comprised of C&D wastes is the only basis for including the landfill in the database.

- The data relied upon were assembled recently by only one organization, using limited data gathering techniques.

REFERENCES

National Association of Demolition Contractors. *C&D Waste Landfills, Leachate Quality Data, Volume 1, Specific State-by-State Responses.* Prepared by Gershman, Brickner & Bratton, Inc. Falls Church, VA, February 18, 1994.

6National Association of Demolition Contractors. *C&D Waste Landfills, Leachate Quality Data, Volume 2, Copies of Reports, Articles, and Other Related Data.* Prepared by Gershman, Brickner & Bratton, Inc. Falls Church, VA, February 18, 1994.

U.S. EPA. *Health Effects Assessment Summary Tables. Annual Update.* Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment. Cincinnati, OH, 1992. OHEA ECAO-CIN-821.

U.S. EPA. *Integrated Risk Information System* (IRIS).

U.S. EPA. *Summary of Data on Municipal Solid Waste Landfill Leachate Characteristics.* Office of Solid Waste. Prepared by NUS Corporation. July 1988.

ATTACHMENT 3-A

OTHER STUDIES OF C&D LANDFILL LEACHATE

ATTACHMENT 3-A
OTHER STUDIES OF C&D LANDFILL LEACHATE

This attachment summarizes the results of selected studies of C&D landfill leachate and compares them to the results of the analysis presented in Chapter 3 of this report (the "NADC/ICF analysis").

THE WMX REPORT

This section compares the results of the NADC/ICF analysis with those of the 1993 *Construction and Demolition (C&D) Landfill Leachate Characterization Study* published by WMX Technologies, Incorporated (the "WMX report"). The WMX report evaluated leachate from four landfills (in Kentucky, Michigan, Massachusetts, and Wisconsin) for all or part of a three-year period (1991 to 1993).[10] Samples from the four landfills were analyzed for 219 organics, 19 inorganics, and 13 conventional parameters.[11] The NADC/ICF analysis evaluated 21 landfills, including the 1991 results from WMX's Kentucky, Michigan, and Massachusetts landfills. Because the NADC/ICF analysis was based on data compiled from various studies, there were significant differences in the parameters sampled for at the 21 landfills. In total, the NADC/ICF analysis covered 242 organics, 26 inorganics, and 37 conventional parameters.[12]

As the remainder of this section will show, the results of the NADC/ICF analysis and the WMX report are quite similar. Below, the two studies are compared in terms of the following factors:

- The number and percent of parameters detected;
- Parameters detected at concentrations exceeding regulatory and/or health-based benchmarks; and
- Parameters that are potentially problematic (i.e., detected at more than one landfill and have median leachate concentrations above a benchmark).

This information is summarized in Table 3A-1 and discussed in the remaining sections.

Organics

In both the NADC/ICF and WMX reports, the percent of organics detected in C&D leachate was low compared to inorganics and conventional parameters. In the NADC/ICF analysis, 14 percent of the organics sampled for were detected (34 out of 242), compared to 15 percent (33 of 219) in the WMX report.

TABLE 3A-1
COMPARISON OF NADC/ICF AND WMX STUDIES[a]

Parameter Type	Number of parameters detected/sampled	Parameters with maximum concentrations exceeding benchmarks	Parameters that are potentiall (ratio of median leachate concentr

[10] Results from an Ohio landfill sampled in 1991 and included in an earlier WMX report were discarded because WMX later discovered that steel mill slag had been used in the leachate collection system and had contaminated the leachate.

[11] Although iron was categorized as a conventional parameter by the WMX report, it is counted here as an inorganic parameter to be consistent with the NADC/ICF analysis.

[12] This includes some double-counting of parameters because similar parameters were reported differently in different studies. For example, nitrate and nitrite were reported separately in one study but together in another study, so the ICF analysis counts three separate categories: nitrate, nitrite, and nitrate/nitrite.